Announcements

- EXAMs will be returned at the END of class today!
- Homework for tomorrow…

  Ch. 29: CQ 4 & 5, Probs. 6, 12, & 44

- Office hours…

  MW 10-11 am

  TR 9-10 am

  F 12-1 pm

- Tutorial Learning Center (TLC) hours:

  MTWR 8-6 pm

  F 8-11 am, 2-5 pm

  Su 1-5 pm

Chapter 29

Potential & Field

(*Sources of Electric Potential & Finding the Electric Field from the Potential*)

Review…

- *Electric potential difference* from the *Electric field*…

$$\boxed{\Delta V = -\int_i^f \vec{E} \cdot d\vec{s}}$$

$d\vec{s}$ = infitecimal displacement
$\vec{E}$ = Electric field

- *Graphically:*
  - ΔV = *negative* of the area under the *E* vs. *s* curve between s_i & s_f

- *Emf* of the battery is the *work done per charge.*

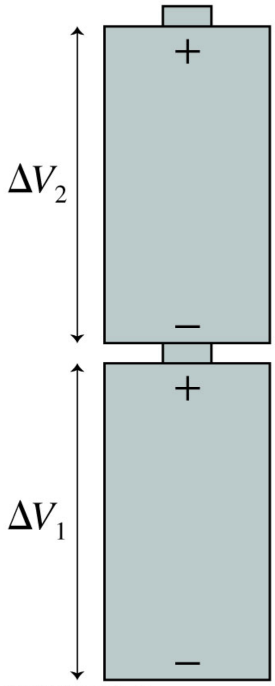
$$\boxed{\Delta V_{bat} = \frac{W_{chem}}{q} = \mathcal{E}}$$

Batteries and emf

Q: What is the *potential difference* of two batteries in series?

- A: The *sum* of their terminal voltages.

$$\Delta V_{series} = \Delta V_1 + \Delta V_2 + \ldots$$

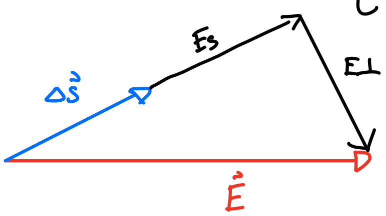


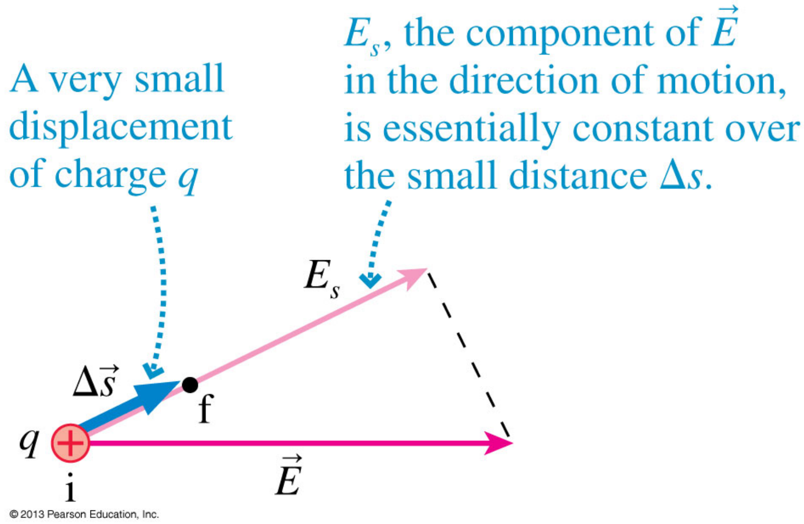
29.3:
Finding the *E*-field from the Potential

Calculate the *potential difference* between points *i* and *f*...

- over small distances Δs, the $\vec{E}$ Field constant....
- The work done by the Force

$$W = \vec{F}\cdot\Delta\vec{s} = q\vec{E}\cdot\Delta\vec{s}$$





$$V = qE_s\Delta s$$

$$qE_s\Delta s = -\Delta U$$

$$\Delta U = q\Delta V \quad \therefore \quad -E_s\Delta s = \Delta V$$

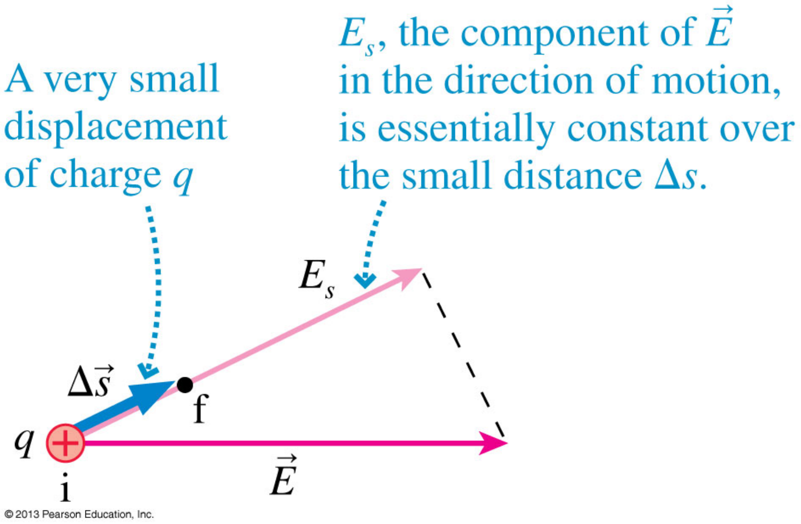
$$E_s = \frac{-\Delta V}{\Delta s} \qquad \Delta s \text{ Limit} = \frac{-dV}{ds}$$

29.3: Finding the *E*-field from the Potential

Calculate the *potential difference* between points *i* and *f*...

$$\boxed{E_s = -\frac{dV}{ds}}$$

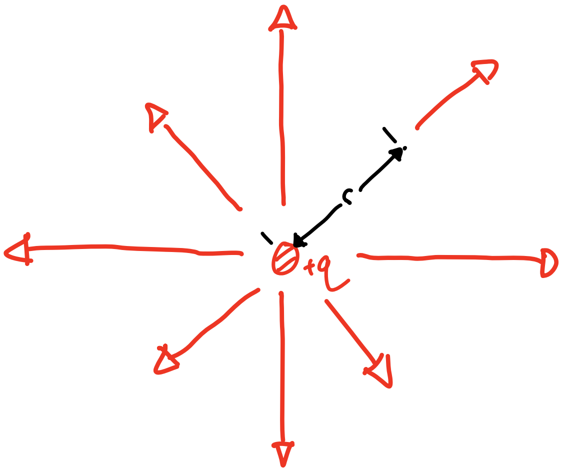
Component of *E*-field
in the *s* direction!



Finding the *E*-field from the Potential

i.e. Calculate the *E*-field of a point charge from the *electric potential*…

ie



$$V = \frac{KQ}{r}$$

Symmetry requires

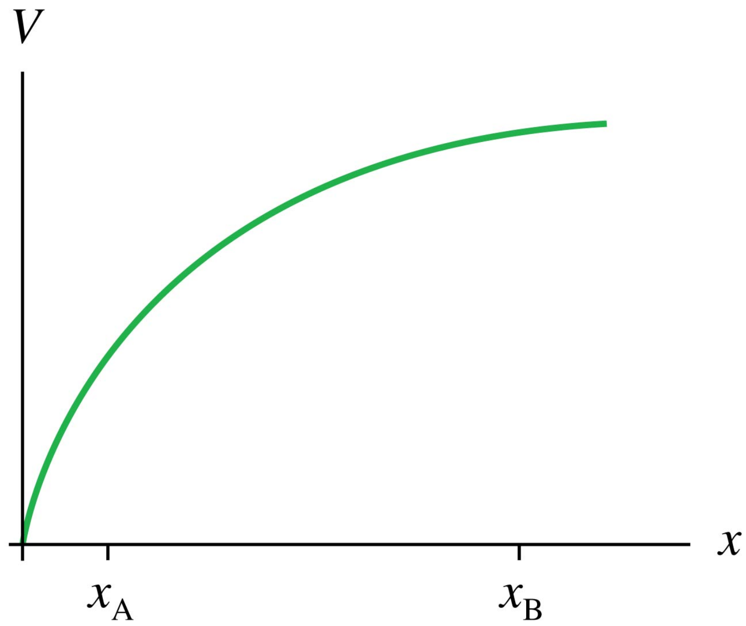
$$E = \frac{dV}{dr}$$

$$= \frac{-d}{dr}\left(\frac{KQ}{r}\right) = -Kq\frac{d}{dr}r^{-1}$$

$$= \frac{KQ}{r^2}$$

Quiz Question 1

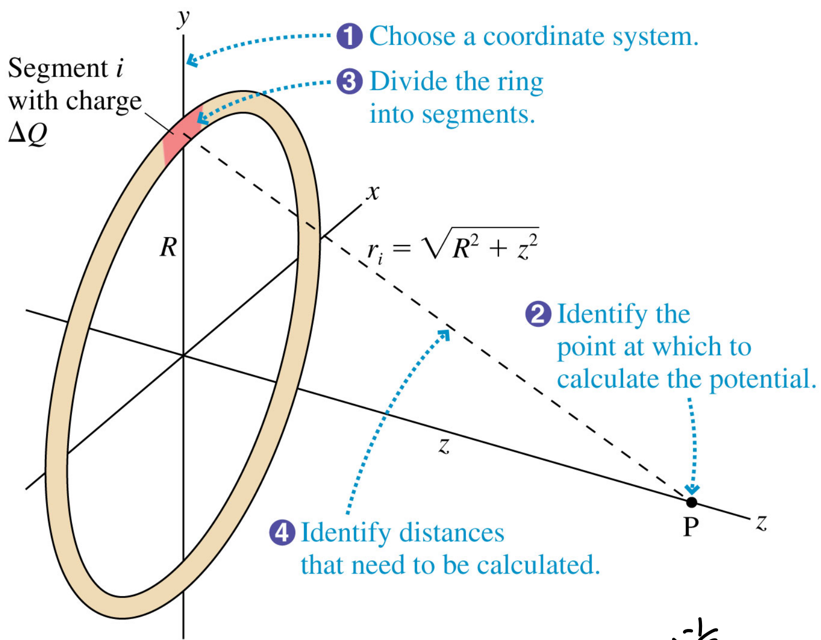
At which point is the E-field stronger?



1. At x_A.
2. At x_B.
3. The field is the same strength at both.
4. There's not enough information to tell.

i.e. 29.3
The *E*-field of a ring of charge

i.e. Calculate the *E*-field (on axis) of a ring of charge from the *electric potential*...



$$V_{ring} = \frac{KQ}{\sqrt{z^2 + R^2}}$$

$$\nabla_R = \frac{-KQ}{\sqrt{z^2+R^2}}$$

$$(z^2+R^2)^{-1/2}$$

$$-\frac{1}{2}(z^2+R^2)^{-3/2} \cdot 2z$$

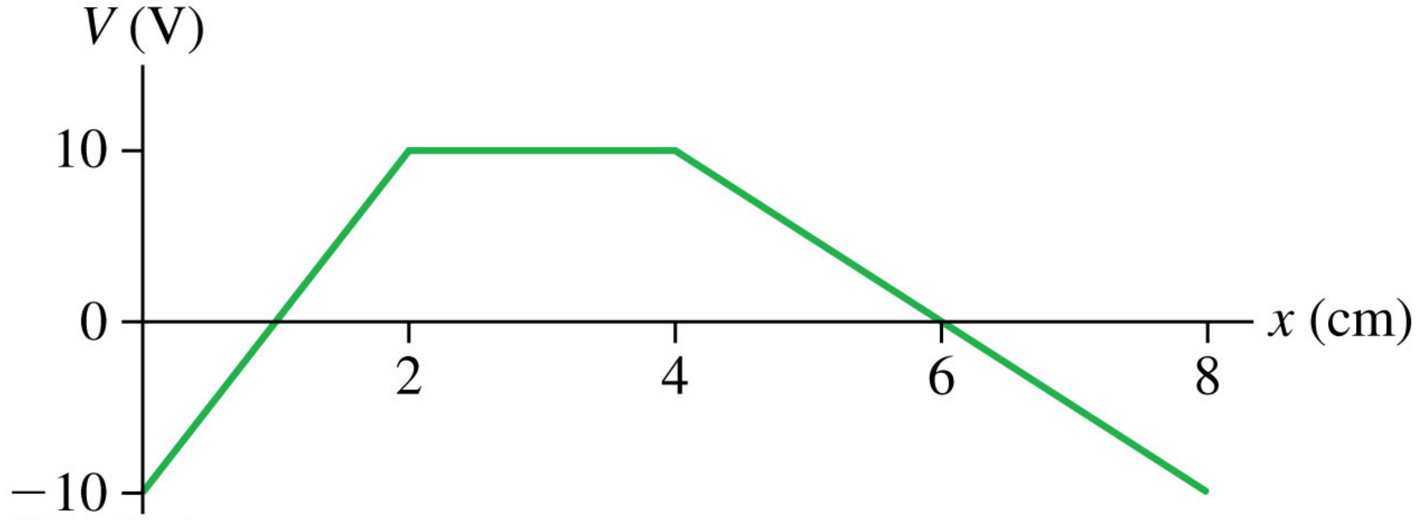
$$(-KQ)\,\frac{-z}{(z^2+R^2)^{3/2}}$$

$$= \frac{KQz}{(z^2+R^2)^{3/2}}$$

i.e. 29.4
Finding E from the slope of V

The figure below is a graph of the electric potential in a region of space where E is parallel to the x-axis.

Draw a graph of E_x versus x.



$0\,cm < x < 2\,cm$ $\quad \frac{\Delta V}{\Delta x} = \frac{20V}{2\times10^{-2}m} = 1000\,V/m$

$E_x = -1000\,V/m$

$2\,cm < x < 4\,cm$ $\quad E_x = 0\,V/m$

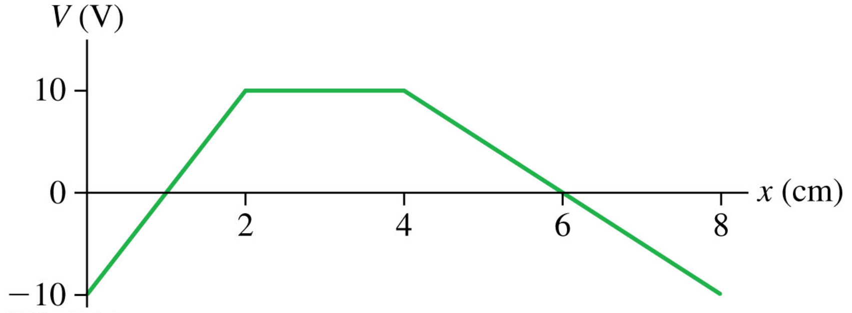
$4\,cm < x < 8\,cm$ $\quad \frac{\Delta V}{\Delta x} = \frac{-20V}{4\times10^{-2}m} = -500\,V/m$

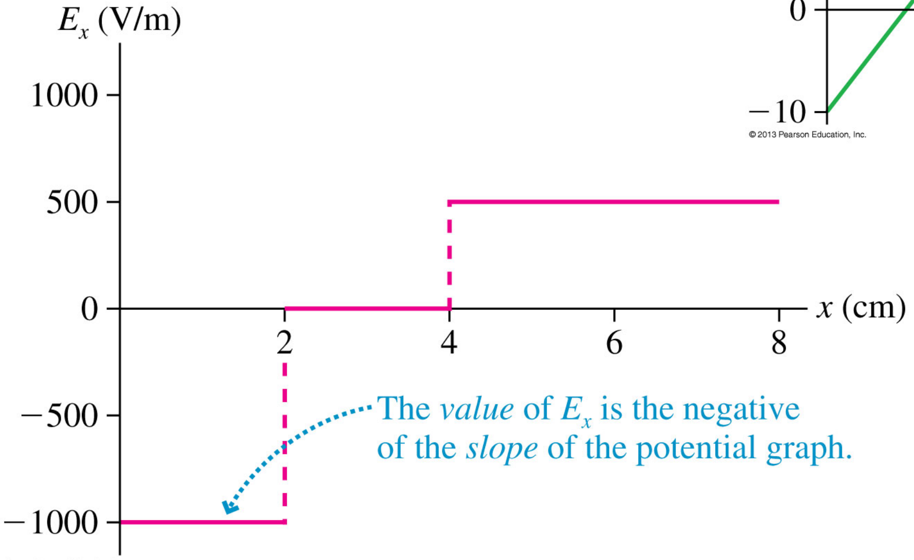
$E_x = 500\,V/m$

i.e. 29.4
Finding *E* from the slope of *V*

The figure below is a graph of the electric potential in a region of space where *E* is parallel to the *x*-axis.

Draw a graph of E_x versus x.





The Geometry of Potential and Field

Consider two *equipotential* surfaces, with V_+ positive relative to V_- ...

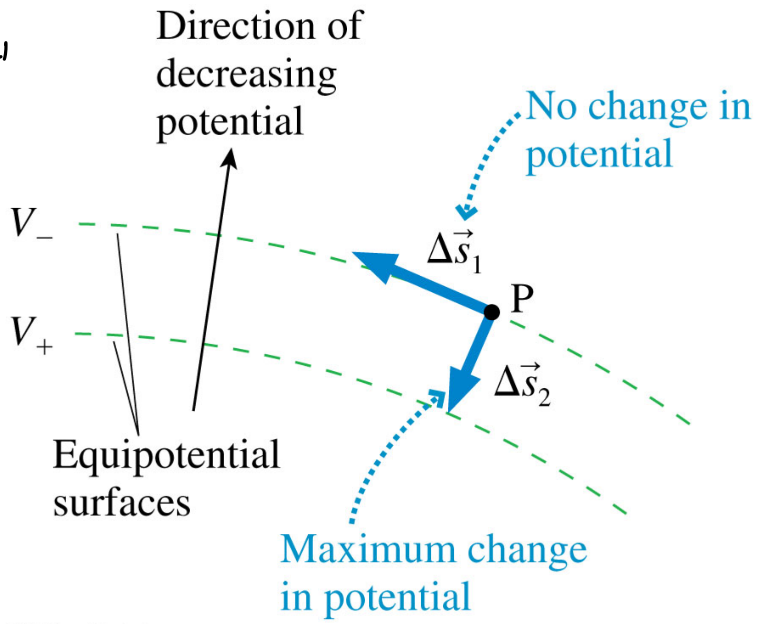
Notice : $\Delta\vec{s}_1$ is tangent to V_-

$\therefore \Delta V \therefore \vec{E}$ tangent to Equipotential line is Zero

$E_1 = 0$

$$E_\perp = \frac{-dV}{ds_2} = -\left(\frac{V_+ - V_-}{\Delta s_2}\right)$$

$V_+ > V_-$, $V_+ - V_- > 0$

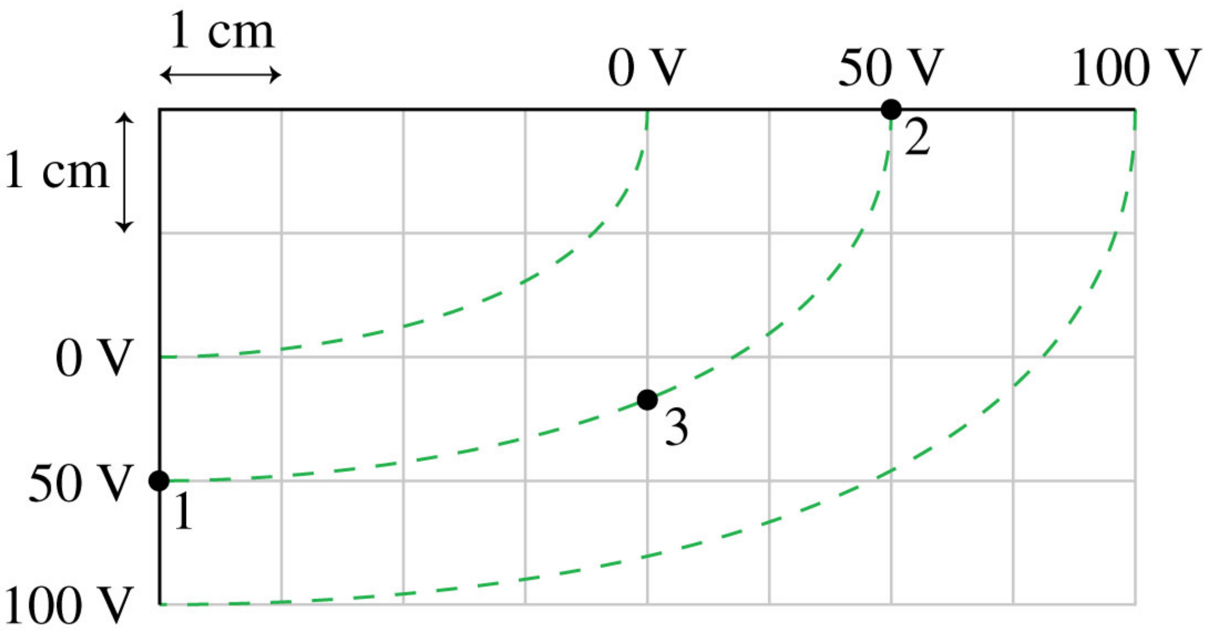


Notice:

- *E* is *perpendicular* to the *equipotential surfaces* and points "downhill" in direction of *decreasing potential.*

i.e. 29.5: Finding the *E*-field from the equipotential surfaces

Estimate the *strength* and *direction* of the *E*-field at pts. 1, 2, & 3.



$$\frac{\Delta V_2}{\Delta s} = \frac{100\,V}{4\times 10^{-2}\,m} = 2{,}500\ V/m$$

i.e. 29.5: Finding the *E*-field from the equipotential surfaces

Estimate the *strength* and *direction* of the *E*-field at pts. 1, 2, & 3.